Mathematical and Theoretical Biology Institute

U.S.A. the Fast Food Nation: Obesity as an Epidemic

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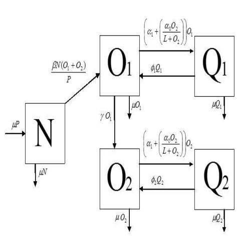
The prevalence of overweight individuals and obesity has increased dramatically in the Unites States. Obesity has become a disease of epidemic proportions. One billion adults worldwide are overweight and of these 300,000 are obese. In particular, 64% of U.S adults and 15% of children and adolescents are overweight. Two major factors have contributed to the epidemic of obesity: changes in individuals behavior and environment. Data indicates that by 1970, Americans were spending $6 billion on fast food, and by 2000 they were spending about $110 billion. By 2002, fast food consumption accounted for more than 40% of a familys food budget. This and fast-food accessibility is partly to blame for observed patterns of obesity and overweight.

The aim of this project is to study the potential role of peer-pressure in fast-food consumption as well as its effect on an individual's weight. We explore these effects on the dynamics of obesity at the population level using an epidemiological model. In this framework, we can explore the impact of intervention strategies. Statistical data analysis provides insights on the relation between demographic factors and weight.

We developed an epidemiological model in which we consider the total population of the United States. This model allowed us to analyze the progression rate from normal weight individuals(N) to overweight (O_1) and obese(O_2) individuals. The classification of N, O_1, O_2 individuals is based on their *BMI* (*Body Mass Index*), which is a number calculated by the individual's weight and height. The progression from normal to overweight individuals is measured by incorporating a peer pressure, β, by which individuals start eating at fast food restaurants. People start eating at fast food restaurants not only because other people invite them to come along but also because of socio-economic status such as accessability and convenience to fast food restaurants. For this project, we are assuming that eating at fast food restaurants increases the individual's weight. If overweight individuals continue to eat at fast food restaurants they can become obese individuals, $O_2(t)$. Both classes can stop eating fast food, and then move to quitting classes, $Q_i(t)$, for $i = 1,2$ for O_1 and O_2 respectively.
Our model is presented next:



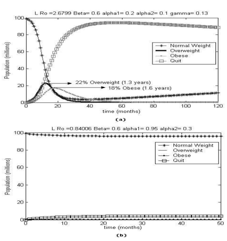
Obesity Model

The non-linear differential equations system is:

$$
\begin{aligned}
\frac{dN}{dt} &= \mu P - \beta N \frac{(O_1+O_2)}{P} - \mu N,\\
\frac{dO_1}{dt} &= \beta N \frac{(O_1+O_2)}{P} + \phi_1 Q_1 - (\gamma+\mu+\Phi) O_1,\\
\frac{dO_2}{dt} &= \gamma O_1 + \phi_2 Q_2 - \mu O_2 - \Psi O_2,\\
\frac{dQ_1}{dt} &= \Phi O_1 - (\phi_1+\mu) Q_1,\\
\frac{dQ_2}{dt} &= \Psi O_2 - (\phi_2+\mu) Q_2,\\
P &= N + O_1 + O_2 + Q_1 + Q_2
\end{aligned}
$$

where $\Phi = \alpha_1 + \frac{\alpha_0 O_2}{L+O_2}$ and $\Psi = \alpha_2 + \frac{\alpha_0 O_2}{L+O_2}$

In order to analyze our model, we considered several cases: a nonlinear quitting model, a nonlinear quitting model without relapse, and a linear model with relapse. To explore the dynamics of our models, we calculated the R_0, which is defined as the average number of secondary cases produced by a typical infected individual. After analyzing each individual case, a common result was obtained: β (peer pressure to become a fast food eater) was the most sensitive parameter and hence has the strongest effect in reducing R_0.



Peer Pressure to Stop Eating Fast Food

Figure (**??**) shows the effect of peer-pressure for the overweight individuals to stop eating fast food, α_1. In Figure (a), α_1 is given a low value, $\alpha_1 = 0.2$, which results in $R_0 = 2.679 > 1$. From the dynamics of the model, we are able to predict that in 15 months (1.3 years), 22% of the normal weight individuals will become overweight. Consequently, in only 18.5 months (1.6 years), 18% of the normal weight individuals will become obese. Now, in Figure (b), the value of α_1 changes to $\alpha_1 = 0.95$, decreasing R_0 to 0.804, the obesity epidemic is under control. With this choice of α_1, the normal weight individuals will progress to the overweight compartment, however since α_1 is high, these individuals will also leave the compartment at a fast rate, hence not advance to obesity.

The models with the support of the numerical analysis, showed that peer-pressure, β had a strong influence on individuals to become a fast-food eater. Furthermore, the rate at which individuals stop eating fast food, α_1 also seemed to be effective in controlling the obesity epidemic. It would appear that in order to reduce the current obesity rates, we should focus on lowering the peer pressure from fast food eaters. However, controlling β is difficult to achieve since β is deduced from the peer-pressure due to frequent fast food eaters, social and economic status. Hence, we should gear our attention in incrementing the peer pressure to stop eating fast food, α_1. This is a more realistic approach since it is easier to increment health awareness programs that are accessible to the general public. Furthermore, the statistical analysis showed a correlation between an individual's weight, education and race.

Acknowledgements

We would like to thank Carlos Castillo-Chavez for the opportunity to conduct this research with the Mathematical and Theoretical Biology Institute. Thanks for the grants from Theoretical Division at Los Alamos National Laboratory (LANL), National Science Foundation, National Security Agency, Provost Office at Arizona State University, and Sloan Foundation. Special thanks to Leon Arriola, Armando Arciniega, Faina Berezovsky, Gloria Crispino, Christopher Kribs-Zaleta and Mahbubur Rahman for their contribution.

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